3.5. TREATMENT: IMPLANT

Authors: Mark Frankle, Jason Hsu

QUESTION 1: What is the optimal implant for treatment of acute periprosthetic joint infection (PJI): reverse total shoulder arthroplasty (TSA), anatomic total shoulder arthroplasty (aTSA) versus hemiarthroplasty?

RECOMMENDATION: The optimal implant for treatment of acute PJI is dependent on the status of the rotator cuff, humeral and glenoid bone stock, and patient factors.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 96%, Disagree: 0%, Abstain: 4% (Unanimous, Strongest Consensus)

RATIONALE

Acute shoulder PJI is most commonly considered to be an infection presenting within 3 months after index arthroplasty as described by Sperling et al. [1]. In this scenario, the surgeon has a number of options in the treatment of acute PJI including antibiotic treatment alone, debridement with or without exchange of modular components, single stage complete exchange, two-stage exchange with antibiotic spacer, indefinite implantation of an antibiotic spacer and resection arthroplasty.

Methodology

Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, we conducted a systematic review to identify all studies concerning diagnosis and treatment of "infection" at the time of revision shoulder arthroplasty. We searched for all studies published in English using the terms (("revision" OR "failed") AND "shoulder" AND ("arthroplasty" OR "replacement")) limited to dates between January 1, 1996 and February 3, 2018. A total of 2,354 studies were identified. We reviewed the titles and abstracts of all studies and excluded studies that included patients with shoulder infection without arthroplasty or included patients with arthroplasty of joints other than the shoulder. The reference lists for all included studies were searched for any additional references and three references were added to our list. A total of 42 studies met inclusion criteria and were included in the final analysis. Relevant data were extracted from the selected publications, including stratification of acute/subacute/chronic classification, procedures performed, final implants, reinfection rates and functional/clinical results.

Results are summarized in Table 1. Of 42 studies, 19 stratified acute PJI from subacute/chronic PJI with 20% of included patients (93/459) in the acute category. While there were a fair number of studies that described patients with acute PJI, the types of implants explanted and implanted were not regularly reported or stratified; and, therefore, drawing conclusions regarding reinfection rates and clinical outcomes was limited. Also, a clear obstacle in synthesizing the literature was that no consensus definition for shoulder PJI was utilized by these studies [2], and defining reinfection is highly variable in the literature, making the optimal implant of choice for treatment difficult to determine. It should be noted that this review does not include data based on duration of symptoms which may play an important role in choice of intervention.

Indications for Irrigation and Debridement

Irrigation and debridement (I&D) with component retention or exchange of modular components is often considered a reasonable option in acute PJI. This has variable outcomes in the literature with regards to reinfection rates and clinical outcomes (Table 2) [1,3–12]. When aggregated, these 11 studies report a **42% recurrence rate for acute PJI treated with I&D** (19 of 45 patients). Given this data, the surgeon must weigh the risks of recurrent infection with and morbidity of implant removal. The decision on whether to perform an I&D may also depend on the acuity of symptoms with some studies suggesting low recurrence when performed within 2 weeks of symptom onset, even when the time between index surgery and symptom onset is prolonged [6,12] (i.e., secondary hematogenous infection [13]).

Indications for Reverse Shoulder Arthroplasty

Conversion to reverse shoulder arthroplasty may be preferred to an anatomic implant in cases of rotator cuff deficiency and proximal humeral and or glenoid bone loss [6,14,15]. In the setting of a prosthetic shoulder infection, a thorough debridement is required and often necessitates resection of necrotic and infected tissue for adequate infection control. Both infection and soft tissue loss are associated with poor functional outcomes after revision arthroplasty, and implantation of an anatomic implant may not be able to sufficiently compensate for rotator cuff loss and/or instability [15–17]. A reverse implant may better compensate for soft tissue loss or bony deficiency [15,18] and can improve pain control and functional recovery without a high recurrent infection rate in some studies [4,19–22].

In some reports, treatment with a reverse shoulder arthroplasty as a treatment for failed arthroplasty is associated with sub-optimal functional results and a high rate of complication [23–30]. Therefore, hemiarthroplasty should be a consideration in cases in which minimizing complications and further surgery is a priority [31,32].

Indications for Hemiarthroplasty

In cases of acute PJI in a shoulder with an intact rotator cuff, revision to hemiarthroplasty is also a reasonable option with potentially similar results to reverse arthroplasty in the setting of infection [19,33,34]. In addition, in some cases of substantial glenoid bone loss, recurrent instability of a reverse and patient factors, such as

TABLE 1. Studies stratified by infection, acuity and implant type

Author	Journal	Year	Acuity			Procedure(s)	Final Implant					Reinfection By Implant Type	Functional By Implant Type
			Acute	*Subacute*	*Chronic*		*Hemi*	*TSA*	*Reverse*	*Spacer*	*Resection*		
Achermann	Infection	2013	4	5	7	I&D/partial Single-stage Two-stage	NOT DESCRIBED					1 of 4 recurrence with I&D for acute	No comparison of implant types
Amaravathi	Eur J Orthop Surg Traum	2012	8	22	14	I&D/partial Single-stage Two-stage Resection	2	1	23			unclear reinfection rate, 12 of 44 needed revision	No comparison of implant types
Assenmacher	JSES	2017	1	6	28	Two-stage	19	7	9			5 of 35 recurrence, not stratified by acuity/implant	Pain, FE, and ER similar hemi vs TSA vs reverse ($p = 0.76$)
Beekman	JBJS Br	2010	3	7	1	Single-stage			10	1		3 of 3 recurrence with I&D	Median CM 55
Boileau	JSES	2013	1	2	4	I&D/partial Single-stage Two-stage Resection			8		3	2 of 2 recurrence with I&D, uncertain acuity	Likely reverse only
Braman	JSES	2006	1	2	4	Resection					7	Resection only	Resection only
Buchalter	JSES	2017	NOT STRATIFIED			Two-stage	4	5	10			5 of 19 recurrence, not stratified by acuity/implant	No comparison of implant types
Cheung	CORR	2011	6	0	0	I&D/partial	8	4				2 of 6 recurrence	I&D 'unsatisfactory' in 5 or 12 post op hematoma; no implant types
Coste	JBJS Br	2004	12	6	24	Antibiotics only I&D/partial Single-stage Two-stage Resection	NOT STRATIFIED					2 of 2 recurrence with arthroscopic I&D 4 of 6 recurrence with open I&D - those that were undertaken earlier were successful	No comparison of implant types
Cuff	JBJS Br	2008	NOT STRATIFIED			Single-stage Two-stage			17			No recurrence	Mean ASES 57.0, pain 3.5, SST 4.0

TABLE 1. Studies stratified by infection, acuity and implant type (*Cont.*)

Author	Journal	Year	Acuity			Procedure(s)	Final Implant					Reinfection By Implant Type	Functional By Implant Type
DeBeer	Acta Orthop Belg	2006	NOT STRATIFIED			Resection					7	Resection only	Resection only
Foruria	JSES	2013	NOT STRATIFIED			I&D/partial	45	61	1			10% reucrrence but no stratification	No comparison of implant types
Ghijselings	Acta Orthop Belg	2013	5	7	5	Two-stage Abx spacer Resection			3	6	8	No differentiation between 'early' and 'acute hematog-enous'	Resection patients more satisfied than abx spacer
Grosso	JSES	2012	NOT STRATIFIED			Single-stage	2	7	8			No comparison of implant types	No comparison of implant types
Hsu	JBJS	2016	NOT STRATIFIED			Single-stage	33	14	1			No recurrence in hemi, TSA, or reverse	No comparison of implant types
Ince	JBJS Br	2005	NOT STRATIFIED			Single-stage	15		1			No recurrent in hemi or reverse	Mean CM 33.6, UCLA 18.3
Jahoda	Acta Chir Orthop	2008	1	3	7	I&D/partial Two-stage	NOT STRATIFIED					2 of 6 recur-rent with I&D (mixed acute and subacute)	n/a
Jawa	JBJS	2011	6	14	8	Abx spacer Two-stage	3	2	10	12	1	recurrence in 5 of 28 patients	Reverse: Flexion 74, 5 moderate pain, 5 severe pain TSA/hemi: Flexion 61, 4 mild pain, 1 moderate pain
Jerosch	Arch Orthop Trauma Surg	2003	UNCLEAR STRATIFICATION			I&D/partial Two-stage	NOT STRATIFIED					0 of 2 recurrence with early I&D	n/a
Kelly	CORR	2009	NOT STRATIFIED			Single-stage	1	3	24			No comparison of implant types	No comparison of implant types
Klatte	JBJS Br	2013	4	15	16	Single-stage	19		7			2 of 35 recurrence, acuity unknown	Hemi: CM 43.3 Hemi w bipolar head: CM 56 Reverse: CM 61

TABLE 1. Studies stratified by infection, acuity and implant type (*Cont.*)

Author	Journal	Year	Acuity			Procedure(s)	Final Implant					Reinfection By Implant Type	Functional By Implant Type
Lee	Int Ortho	2017	8	4	0	Two-stage	2		10			No recurrence in hemi or reverse	Pain 2.3, ASES 64.2, CM 66.1
Levy	Orthopedics	2015	NOT STRATIFIED			Spacer				9		No recurrence with abx spacer	Pain 2.0, SST 6.3, ASES 65.8, SANE 54.6
Mahure	Orthopedics	2016	NOT STRATIFIED			Spacer				9		No recurrence with abx spacer	ASES 57
Muh	JSES	2013	NOT STRATIFIED			Resection					22	n/a	n/a
Ortmaier	Eur J Orthop Surg Traum	2014	4	9	7	I&D/partial Two-stage Resection	1		14	1	4	2 of 4 recurrence with I&D in acute 3 of 3 recurrence with I&D in subacute	
Pellegrini	Arch Orthop Trauma Surg	2018	NOT STRATIFIED			I&D Abx spacer				19		no recurrence	CM 38.3, pain 1.5, FE 59.2, Abd 52.5
Rispoli	JBJS Br	2007	NOT STRATIFIED			Resection					18	no report of recurrence	ASES 36, SST 3.1
Romano	Int Ortho	2012	9	21	14	Two-stage Spacer Resection	NOT STRATIFIED					1 of 5 recurrence with I&D	Not stratified "Resection with poorest outcomes"
Sabesan	CORR	2011	8	7		Two-stage			17			1 of 17 recurrence with reverse	Penn 66.4, FE 123, ER 26
Sperling	CORR	2001	4	5	23	I&D/partial Two-stage Resection	NOT STRATIFIED					1 of 2 recurrence with I&D for acute 2 of 4 recurrence with I&D for subacute/chronic	n/a
Stevens	JSES	2015	NOT STRATIFIED			Resection					7	1 of 7 recurrence	n/a
Stine	JSES	2010	0	0	30	Spacer Two-stage	10	1	4	15		0 of 30 recurrence	Inadequate stratification to compare implant types

TABLE 1. Studies stratified by infection, acuity and implant type (*Cont.*)

Author	Journal	Year	Acuity			Procedure(s)	Final Implant					Reinfection By Implant Type	Functional By Implant Type
Stone	JSES	2017	NOT STRATIFIED			I&D/partial One-stage Two-stage	STRATIFICATOIN UNCLEAR					4 of 15 recurrence with I&D, uncertain acuity	
Strickland	JBJS Br	2008	3	7	9	Two-stage	13	5	1			7 of 19 recurrence with two-stage	No comparison of implant types
Themistocleous	JSES	2007	NOT STRATIFIED			Spacer				4		no stratification	n/a
Topolski	JSES	2006	NOT STRATIFIED			Single-stage	NOT STRATIFIED					n/a	n/a
Twiss	Seminars in Arthroplasty	2010	NOT STRATIFIED			Spacer Two-stage	STRATIFICATOIN UNCLEAR					0 of 30 recurrence	n/a
Verhelst	JSES	2011	0	4	17	Spacer Resection				10	11	2 of 21 reucrrence	Inadequate stratification to compare implant types
Weber	Int Ortho	2011	NOT STRATIFIED			I&D/partial Two-stage Resection	NOT STRATIFIED					0 of 1 recurrent for I&D	
Zavala	JSES	2012	5	2	0	I&D/partial Resection			5		2	1 of 4 recurrence with I&D	
Zhang	JSES	2015	NOT STRATIFIED			Two-stage	2	1	15				No comparison of implant types
			Acute	*Subacute*	*Chronic*		*Hemi*	*TSA*	*Reverse*	*Spacer*	*Resection*		
		TOTAL	**93**	**148**	**218**	**TOTAL**	**179**	**111**	**198**	**86**	**90**		
			20%	**32%**	**47%**		**27%**	**17%**	**30%**	**13%**	**14%**		

I&D; irrigation and debridement; TSA, total shoulder arthroplasty

TABLE 2. Success of I&D with component retention or exchange of modular components

Author	Journal	Year	No. Undergoing I&D	No. Recurrent Infection
Achermann	Infection	2013	4	1
Beekman	JBJS Br	2010	3	3
Cheung	CORR	2011	6	2
Coste	JBJS Br	2004	8	6
Jahoda	Acta Chir Orthop	2008	6	2
Jerosch	Arch Orthop Trauma Surg	2003	2	0
Ortmaier	Eur J Orthop Surg Traum	2014	4	2
Romano	Int Ortho	2012	5	1
Sperling	CORR	2001	2	1
Weber	Int Ortho	2011	1	0
Zavala	JSES	2012	4	1
TOTAL			**45**	**19**

noncompliance precluding implantation of a reverse, conversion to a hemiarthroplasty [32] may be the preferred choice to minimize intraoperative and postoperative complications [35].

Indications for Total Shoulder Arthroplasty

While better pain relief and functional scores can be obtained with total shoulder arthroplasty than hemiarthroplasty [36], the rate of polyethylene glenoid component loosening in the setting of revision is high [37]. In the setting of acute PJI, conversion to total shoulder should be strictly limited to cases in which the rotator cuff is fully intact, glenoid bone stock is sufficient, and bacterial burden is minimal.

In select cases, resection arthroplasty [38–42] and indefinite placement of an antibiotic spacer [43–45] can be considered for acute PJI.

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3.6. TREATMENT: RESECTION

Authors: José M. Mora, Simon Lambert

QUESTION 1: What are the indications for resection shoulder arthroplasty in acute periprosthetic joint infection (PJI)?

RECOMMENDATION: There are no available reports on resection shoulder arthroplasty for acute PJI. At this time there is no evidence to routinely recommend this treatment for this indication.

LEVEL OF EVIDENCE: No Evidence

DELEGATE VOTE: Agree: 88%, Disagree: 8%, Abstain: 4% (Super Majority, Strong Consensus)

RATIONALE

Search Strategy

A request via the Royal Society of Medicine Library utilizing ProQuest Dialog, searching Embase and Medline archives. Search terms: (excision arthroplasty) OR (resection arthroplasty) AND (acute periprosthetic infection) OR (chronic periprosthetic infection) OR (subacute periprosthetic infection). Yielded 1,649 references. After limiting these to shoulder-specific references and eliminating duplicates 100 references were further searched for exact matching to the question of the role of resection arthroplasty in the management of acute PJI (subacute or chronic PJI). All full papers, reviews and abstracts in English between 1990 and 2018 were examined, and those reporting the indications and outcomes of resection (excision) arthroplasty of the shoulder were examined further. Personal searches of PubMed archives were performed by both authors using the same criteria, and their searches were compared. The bibliographies of two recent reviews (one specifically examining the question of resection, the value of spacers and one-and two-stage revision arthroplasty in subacute or chronic PJI [1], the other a more general review [2]) were examined for further references and cross-checked with the first enquiry and the personal searches.

No manuscripts were identified which reported on resection shoulder arthroplasty for acute PJI.

Conclusion

The available literature has no evidence pertaining to resection arthroplasty in acute shoulder PJI to provide guidance on this question.